File Test Section Infantry Board

REPORT

of

The Infantry Board

No. 1442

COLORED SMOKE GRENADES

FORT BENNING, GEORGIA

January 15, 1943

24725—Benning, Ga., 9-16-42—2,000

DECLASSIFIED
Authority NND 963026

IB-471.6

January 15, 1943.

Subject: Colored Smoke Grenade.

To: Chief, Ground Requirements Section,
Army Ground Forces, Army War College,
Washington, D. C.

1. The Infantry Board concurs in general with the Discussion and Conclusions of the Report of Test of The Test Section, The Infantry Board.

2. In considering the issue of the subject smoke grenade the overloaded condition of the Infantry must be noted. Before any item is superimposed on the present authorized equipment, it should be clearly established that the item possesses characteristics that will greatly improve the battlefield efficiency of the unit. The subject smoke grenade is not a positive means of identifying ground troops to the air. It is of little value in wooded terrain or in terrain covered with ground mist, smoke or dust. In its present form, it will not replace any of the present means of identifying ground troops to the air. It should be furnished to the Infantry to meet special conditions. When modified to meet the characteristics laid down in the directive (Appendix B) its utility will be greatly increased. A colored smoke parachute signal would replace a percentage of the ground signals.

3. It is the opinion of the Infantry Board that:

a. Colored smoke is a valuable visual means of signal communication.

b. The subject grenades modified as indicated in paragraph 23 of the Report of Test will be a satisfactory supplement to the present means of identifying ground troops to aircraft.

c. Colored smoke parachute signals similar to the one shown in Appendix "F" should be produced and issued to

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replace a percentage of the M17-22 series and the M17A1-22A1 series of Ground Signals.

d. Development should continue on a grenade that will meet the characteristics laid down in the directive (Appendix B). See Test No. 14.

4. The Infantry Board recommends that:

a. Development be continued on a smoke grenade that will meet the characteristics laid down in Appendix B.

b. Colored smoke parachute signals similar to the one shown in Appendix F be produced to replace fifty percent of the M17-22 series and the M17A1-22A1 series of Ground Signals for daytime use.

c. The subject smoke grenade modified as indicated in paragraph 23, Report of Test, be classified as substitute standard for Infantry use until such time as it is equipped with a tail assembly permitting either its projection from the rifle or throwing by hand.

d. The basis of issue of the subject smoke grenade (modified) be determined by the theater commander.

For the President:

H. G. SYDENHAM,
Colonel, Infantry,
Acting Director.

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REPORT of TEST

COLORED SMOKE GRENADES

TEST SECTION
THE INFANTRY BOARD
FORT BENNING, GEORGIA

Submitted to
THE INFANTRY BOARD

Copy No. 6 **Date** Jan. 11, 1943

26068—BENNING, GA., 12-11-42—200

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TEST SECTION
THE INFANTRY BOARD
FORT BENNING, GEORGIA

January 11, 1943

SUBJECT: COLORED SMOKE GRENADES

TO: THE PRESIDENT, THE INFANTRY BOARD, FORT BENNING, GA

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I AUTHORITY AND REFERENCES

1. Authority.

a. Letter, IB-471.6, The Infantry Board, Dec. 15, 1942, Subject, "Colored Smoke Grenades", Appendix "A".

b. Letter, GNR T-11/25390, Ground Requirements Section, Headquarters Army Ground Forces, December 18, 1942, with one (1) inclosure and (1) one Indorsement. Appendix "B".

2. References.

a. Letter, IB-471.6, The Infantry Board, Dec. 15, 1942, Subject, "Grenades, Colored Smoke", Appendix "C".

b. Infantry Board Reports of Test Nos. 1353 and 1424.

II PURPOSE OF TEST

3. a. To determine the suitability of colored smoke grenades as a means of:

(1) Identifying and locating the position of forward Infantry elements to air observers.

(2) Identifying a Cub or liaison plane to ground troops.

b. To determine whether the grenade meets the characteristics stated in basic letter, Appendix "B".

c. To answer test questionnaire found in Inclosure to basic letter, Appendix "B".

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III PERSONNEL

4. a. Major W. M. Myers, Infantry, Test Section, The Infantry Board, conducted the tests and prepared this report. Experimental construction was done by Captain Lawrence Witzen, Test Section, The Infantry Board.

b. Photographs were taken by the Reproduction Plant, The Infantry School, Fort Benning, Georgia.

c. Air observers were furnished by the 7th Observation Squadron, Lawson Field, Fort Benning, Georgia.

IV INTRODUCTORY INFORMATION AND DESCRIPTION OF PROJECT TESTED

5. Introductory information.

a. Colored smoke grenades were requested as test items for the Artillery-Infantry Test concluded at Fort Benning, Georgia, on November 15, 1942.

b. On December 14, 1942, 150 grenades, 25 each in colors red, orange, yellow, green, blue and violet, were received by the Infantry Board.

c. On December 16, 1942, directive was received by the Test Section. Tests were initiated on that date.

d. On December 23, 1942, a second directive was received. See Appendix "B".

e. The Test Section was directed to save several grenades for comparison with a colored powder cloud type signal being shipped to the Infantry Board.

6. Description of project tested:

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a. The subject colored smoke grenades closely resemble the CN gas grenade in appearance. The smoke producing material is enclosed in a canister and is actuated by a bouchon type igniter designed M200A1. The word "SMOKE" and the color is stenciled on the side of the canister, and the top of the canister is painted to correspond to the color of the smoke produced.

b. See Inclosure to basic letter, Appendix "B", for additional information.

V DETAILS OF TESTS AND RESULTS

7. Test No. 1

December 16, 1942.

a. Purpose: To determine the physical characteristics of the subject grenades.

b. Method: By weighing, measuring and photographing.

c. Results:

(1) Measurements: All grenades were of the same size and type, differing only in filling. The measurements given below apply to all:

(a) Overall height - - - - 5-5/8"

(b) Height of can, less bouchon assembly - - 4-3/4"

(c) Diameter of canister - 2-7/16"

(2) Weights:

(a) Bouchon assembly M200A1 - 0.15 lbs.

(b) Canisters:

Red - - - - - - - - - - - - - 1.00 lbs.

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Orange	0.93 lbs.
Yellow	0.94 lbs.
Green	0.92 lbs.
Blue	0.84 lbs.
Violet	0.94 lbs.

(c) Average weight of grenades w/igniter 1.08 lbs.

(3) Appearance: See Plates 1 to 4 inclusive.

8. Test No. 2

December 18, 1942.

a. Purpose: To determine the burning time of the subject grenades.

b. Method: Three grenades of each color were burned and the time recorded.

c. Results:

(1) Table:

Color	Grenade No. 1	No. 2	No. 3	Average
Red	2' 29"	2' 30"	1' 56"	2' 19"
Orange	2' 40"	2' 30"	2' 35"	2' 35"
Yellow	2' 21"	2' 11"	2' 38"	2' 23"
Green	2' 42"	2' 53"	2' 03"	2' 33"
Blue	2' 07"	2' 12"	2' 23"	2' 14"
Violet	2' 03"	2' 40"	2' 07"	2' 37"

(2) The average elapsed time from release of the Pouchon lever to full ignition of the grenade was from 5 to 7 seconds.

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9. Test No. 3

December 18, 1942.

a. Purpose: To determine the effect of cold upon the subject grenades.

b. Method: Two grenades of each color were placed in a cold storage chamber at a temperature of plus 12 degrees Fahrenheit, left for 44 hours and then ignited. Results were noted.

c. Results:

(1) Of the twelve grenades exposed to the cold, only one proved defective. The primer of the bouchon failed to fire. The bouchon was replaced and the grenade ignited readily. The failure was attributed to a defective primer, and not to the cold.

(2) It was the opinion of all observers that the grenade would function satisfactorily under winter conditions.

10. Test No. 4

December 21, 1942.

a. Purpose: To determine the effect of water on the subject grenades.

b. Method: One grenade of each color was dropped in a tub of water and left for 44 hours. Efforts were then made to actuate them, and the results were noted.

c. Results:

(1) The orange, blue, and violet colored grenades ignited and burned. It was noted that ignition was appreciably slower than with the dry grenades, and that the burning time was extended considerably. The orange grenade burned for 3 minutes, 35 seconds. As shown in Test No. 2, the average burning time of this grenade when dry was

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2 minutes, 35 seconds. The blue grenade burned for 2 minutes, 41 seconds. Its average burning time when dry was 2 minutes, 14 seconds. The violet grenade burned for 3 minutes, 07 seconds. This time, while identical to the burning time of one of the dry grenades, was appreciably higher than the average of 2 minutes, 37 seconds.

(2) When an attempt was made to ignite the green smoke grenade the primer fired but the powder train failed to ignite. A second bouchon was tried. The grenade ignited readily and burned satisfactorily. It was determined that the failure was due to a fault in the bouchon and not to the grenade proper.

(3) The red and the yellow grenades failed to ignite although the bouchons functioned perfectly. Upon examination it was found that in each case water had penetrated the tape covering the exhaust holes in the top of the canister and had thoroughly soaked the starting mixture. Both grenades readily ignited when dried and refitted with bouchons.

11. Test No. 5

December 19 and 21, 1942.

a. Purpose: To determine:

(1) The maximum distance, under 5,000 yards, that the subject smoke grenades, actuated and trailed from an observation airplane, can be seen and recognized by ground observers.

(2) The efficacy of using the subject grenades as a means of identifying a Cub or liaison plane to ground troops.

b. Method: Twelve grenades, two in each of the six colors provided, were modified by adding a ring and fifty feet of wire to the grenade base primer. See diagram in Appendix "B". Part of the wire was wrapped around the bouchon lever to produce delayed ignition when grenades were dropped from the airplane. The plane flew a course as shown in the diagram below, acquainting the ground observers with its position distance by radio periodically. Test altitudes were 600 and

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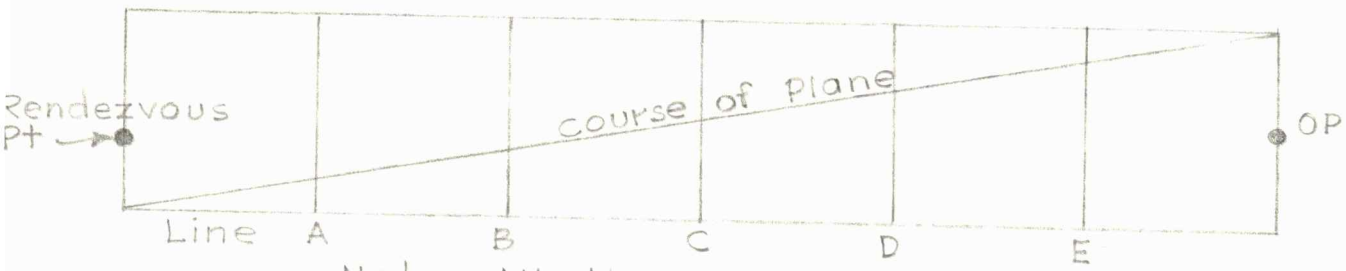
1500 feet. Notes were made on the position of the plane, (1) when the smokes were first seen, and (2) when the colors were recognized, and the distance involved were computed. See Appendix "G-1" for record blank issued to all observers.



Note: All lines are 1000 yds apart

c. Results:

(1) Part 1: Altitude - 600 feet.
Ceiling -2000 feet.
Visibility - 8 miles.
Time - 1400-1600 hrs.
Light grey cloud background.

(a) Table:

Color	Distance seen	Distance recognized	Remarks
Red	5000 yds.	2000 yds.	Color indefinite.
Orange	2000 yds.	500 yds.	
Yellow	1000 yds.	1000 yds.	
Green	3000 yds.	1000 yds.	
Blue	5000 yds.	3000 yds.	Looked black at time
Violet	5000 yds.	3000 yds.	

(b) At best, all colors were very indistinct and none of the observers were positive of their identification until the plane was within a few hundred yards of their position.

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(c) The smoke stream was dissipated immediately by the slip-stream of the plane. It was the opinion of all observers that it was of insufficient volume to be considered satisfactory for this purpose.

(2) Part 2: Altitude - 1,500 feet.
Ceiling - Unlimited.
Visibility - Unlimited.
Time - 1000 to 1100 hrs.
Blue sky background.

(a) Table:

Color	Distance seen	Distance Recognized	Remarks
Yellow	4000 yds.	500 yds.	Looked white, green & yellow at distances greater than 500 yds.
Blue	5000 yds.	3000 yds.	Looked black at 4000 yds.
Violet	4000 yds.	1000 yds.	Appeared grey at distances over 1000 yds.

(b) This test was terminated sooner than planned because the individual operating the grenades became ill. The results agree generally with the findings shown in Part 1, above.

(3) While the grenade is easy to modify and use for this purpose, the difficulty of positively identifying the colors makes their use as a means of identifying a Cub or liaison plane of doubtful value. Only the red and blue colors could be recognized at the minimum operating distance of these planes.

12. Test No. 6

December 23, 1942.
Ceiling - High scattered clouds.
Visibility - 8 miles.
Wind - 8 mph.
Background - Light brown.

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a. Purpose: To determine the maximum distances under 6,000 yards that the subject smokes ignited by ground troops can be seen and recognized by air observers flying at prescribed altitudes.

b. Method: Four airplanes flew a known course at altitudes of 600, 2,000, 5,000 and 10,000 feet, from a rendezvous point 6000 yards distant from the display area. See diagram in Par. 11 b, above. Grenades were ignited and the planes notified by radio to approach the display area. Air observers noted, (1) their position when smoke was first seen, and (2) their position when the color was definitely established. The test was divided into four parts:

(1) Part 1 - Six flights. One grenade was burned during each flight.

(2) Part 2 - Six flights. Two grenades of the same color were burned simultaneously during each flight.

(3) Part 3 - Five flights. Two grenades of different colors were burned 100 feet apart for each flight to determine likelihood of confusing colors. The following combinations were tested:

(a) Red - Orange.

(b) Blue - Violet.

(c) Yellow - Green.

(d) Red - Violet.

(e) Blue - Green.

(4) Part 4 - Questionnaire. Air observers were given questionnaires. See Appendix "C-2" for questionnaire and record forms.

c. Results:

(1) Part 1 - Single grenade:

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Flight	Color	600 Seen	600 Recog	2000 Seen	2000 Recog	5000 (a) Seen	5000 (a) Recog	10000 Seen	10000 Recog
1	Violet	2000	1000	2000	1000	Did not see		3000	3000	Did not see	
2	Green	4000	2000	4000	4000	6000	6000	5000	5000	5000	5000
3	Red	6000	5000	6000	2000 (b)	6000	6000	6000	6000	6000	4000
4	Yellow (c)	5000	2500	6000	2000	6000	1000	6000	4000	6000	3000
5	Orange	6000	5000	6000	5000	6000	5000	6000	6000	5000	1000 (d)
6	Blue (e)	3000	1000	6000	1000	2000	??	6000	4000	6000	2000

(a) Two observers flew at 5000 feet.

(b) Looked orange to this observer at 6000, 5000, 4000 and 3000 yards.

(c) Looked white or pale green at distances over 2000 yards. Very eye-arresting but color indistinct.

(d) This observer recorded "brown".

(e) Observers stated that blue and violet colors blended with ground and haze and were difficult to pick up.

(2) Part 2 - Two grenades of the same color burned simultaneously.

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Flight	Color	600		2000		5000				10000	
		Seen	Recog	Seen	Recog	Seen	Recog	Seen	Recog	Seen	Recog
1	Red	6000	6000	6000	2000 (a)	6000	6000	6000	6000	6000	5000
2	Blue	6000	4000	5000	3000	6000	3000	6000	6000	6000	6000
3	Orange	6000	3000 (b)	6000	4000	6000	6000	6000	6000	6000	5000
4	Violet	6000	4000	5000	3000	6000	3000	6000	6000	6000	6000
5	Yellow (c)	6000	3500	6000	3500	5000	5000	6000	6000	6000	6000
6	Green	6000	6000	6000	5000	6000	6000	6000	6000	6000	6000

(a) Looked orange to this observer until 2000 yd. line was reached.

(b) Confused with red at greater distances.

(c) Observers noted that yellow has greenish cast as it becomes disappated, but is quite eye arresting.

(3) Part 3 - Colors liable to be confused.

(a) Only the red and orange colors were confused and these at distances in excess of 3000 yards.

(b) In all other instances, while colors themselves could not be identified at the extreme distances, sufficient difference in shading existed to prevent confusion of the two colors.

(c) It was the opinion of the air observers that either red or orange should be eliminated from the series.

(4) Questionnaire synopsis:

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Question	Observer A	Observer B	Observer C	Observer D	Observer E
(a) Are all colors distinctive?	Fairly so	No	- -	Yes, from 400 yds.	No
(b) If not, what colors are liable to be confused?	Red-orange yellow-white	Red-Orange Blue-purple yellow-white	Red-orange Blue-black battle-field	Yellow looks greenish when used alone	Blue-purple
(c) What colors do you consider satisfactory for locating ground troops?	Orange, green, red when not used with orange, yellow when not used with white.	Red, green.	Red or orange, green, yellow.	Red, purple.	Red, yellow
(d) Do you consider any of these colors particularly unsatisfactory - If so, which ones?	Blue, purple.	Blue, purple.	Blue, purple	None	Orange, blue.
(e) Is the burning time adequate? Could it be reduced? To what time length?	Yes No. ***	Yes ***	Yes Yes ***	Yes Yes ***	Yes Yes 1/2 present.
(f) Is the volume adequate to insure location?	Double-yes. Single-maybe	Yes, both single and double	No	Yes	Double-yes. Single-only most distinctive colors.

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13. Test No. 7

December 24, 1942.

Weather- Cloudy, slight haze.
Background - Brown and dark green.

a. Purpose: To determine the distinctiveness and relative effectiveness of the subject smokes when viewed at increasing distances by ground observers.

b. Method: Observation posts were located giving views of the subject smokes from distances of 1000, 1800, and 3400 yards. The smokes were ignited in an order unknown to the observers who were asked to identify the color and then rate the six colors for each distance. See Appendix "C-3" for the observers report form.

c. Results:

(1) Distance: 1000 yds.

(a) All colors were easily identified at this range.

(b) Ratings of the four observers were:

Color	Observer A	B	C	D	Average Rating
Red	3	4	3	3	3.25
Orange	2	5	2	5	3.5
Yellow	1	1	1	2	1.25
Green	5	4	4	3	4.0
Blue	6	6	5	6	5.75
Violet	4	2	6	1	3.25

(c) Unanimity of opinion on the best, yellow, and the worst, blue, at this distance is quite evident, as is also decided differences of opinion as to the relative effectiveness of the other four colors.

(2) Distance: 1800 yds.

(a) At this distance, orange and red were difficult to identify positively because of their similarity.

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It was also noted that the yellow smoke had a greenish cast particularly around the outer periphery of the cloud.

(b) Ratings of the four observers were:

Color	Observer A	B	C	D	Average rating
Red	1	1	1	4	1.75
Orange	4	4	3	5	4.0
Yellow	3	3	2	2	2.5
Green	5	4	4	3	4.0
Blue	6	6	6	6	6.0
Violet	2	2	5	1	2.5

(c) All colors were rated as satisfactory at this distance. It will be noted that again blue was considered the least effective of the six colors. Red was considered the most effective by the majority of observers.

(3) Distance: 3400 yards.

(a) At this distance, blue and purple were considered unsatisfactory by the majority of observers because they blended into the background and were difficult to distinguish.

(b) Ratings of the four observers were:

Color	Observer A	B	C	D	Average rating
Red	3	3	3	3	3.00
Orange	4	3	4	5	4.00
Yellow	1	3	2	2	2.0
Green	2	1	1	1	1.25
Blue	6	6	6	6	6.00
Violet	5	5	4	5	4.75

(4) Composite ratings:

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Color	Distance 1000 yds	1800 yds	3400 yds	Average
Red	3.25	1.75	3.0	2.67
Orange	3.5	4.0	4.0	3.83
Yellow	1.25	2.5	2.0	1.92
Green	4.0	4.0	1.25	3.08
Blue	5.75	6.0	6.0	5.92
Violet	3.25	2.5	4.75	3.5

(b) It was noted that two of the three green signals burned instead of smoked. It was the opinion of the test officer that the amount of coolant had been incorrectly calculated, and that this difficulty could be overcome merely by increasing the proportion of coolant in the mixture.

14. Test No. 8

December 26, 1942.

a. Purpose: To determine the effect of high temperatures on the subject grenades.

b. Method: One grenade of each color was placed in a laundry drying room at a temperature of 120° F. and left for six hours. At the end of this period the grenades were ignited and their functioning noted.

c. Results: The exposure to high temperatures had no apparent effect on either the igniters or the smoke mixture. The grenades ignited and burned readily.

15. Test No. 9

December 30, 1942.

Hours - 1400 to 1600.
Visibility - 8 miles.
Ceiling - 4000 feet.
Sky overcast.

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a. Purpose: To determine the effectiveness of the grenades used tactically in designating the positions of front line Infantry troops to an artillery observation airplane flying at an altitude of 600 feet and to a Corps Reconnaissance Airplane flying at an altitude of 1500 feet.

b. Method: A tactical situation was evolved based on a Battalion of Infantry in the Attack. Positions of platoon headquarters were located tactically. The two airplanes flew generally 1500 yards behind the last known position of our own front lines and called for a display of identification through a radio net including the SCR-AL-183 in the Corp Reconnaissance Airplane and SCR-536 radios in the hands of acting platoon leaders. Positions so designated were marked by the air observers on maps and their accuracy checked at the conclusion of the test. The test included three front line designations in which all colors of grenades were used.

c. Results:

(1) Table:

Identification Signals Number	Employed	Obs. A(600 ft)	Obs.B(600 ft)	Obs.C(1500 ft)
1	Four -			
	2 red	2 unknown	1 unknown	1 red
	2 green	2 green	1 green	1 green
2	Four -			
	2 blue	2 blue	2 blue	2 blue
	2 orange	1 orange(1)		1 orange
3	Four -			
	2 yellow	2 yellow	2 yellow	2 yellow
	2 violet	1 violet(2)	1 violet.	1 unknown

Note (1): Both orange grenades were in deep woods.

Note (2): One violet grenade was one deep woods.

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(2) The following observations were made:

(a) The red smoke, while it could be seen above trees, was of an indistinct color. It looked more like a pink mist than like a red smoke. Two observers failed to identify the color. The third was high enough to be able to see the smoke near its source.

(b) The smokes in very thick woods were relatively ineffective because they were so dissipated when tree top level was reached that identification was difficult. Green, yellow and blue retained enough color to be identified easily from the distances employed in this test.

(3) The average error in marking position was 47 yards.

16. Test No. 10

December 29, 1942.

a. Purpose: To determine whether the grenades meet the characteristics stated in basic letter, Appendix "A".

b. Method: The listed characteristics were studied in light of the test results so far obtained. These characteristics are reiterated for reference purposes:

(1) Purpose: To generate small clouds of colored smoke on the ground or in the air between 100 and 300 feet above the ground, for indicating to friendly aircraft the location of front line elements of ground troops or identifying friendly ground installations and areas.

(2) Type and Method of Employment: Small smoke pots or grenades to be ignited and placed or thrown by hand on the ground and also capable of being projected vertically into the air to a height of between 100 and 300 feet for aerial bursts or for generation of the smoke while supported by a suitable parachute. If technically feasible the same ammunition should be susceptible of either method of employment at will.

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(3) Method of Projection: By hand or with standard pyrotechnic projectors in use by the ground arms. Projection with the M1 launcher on the Rifle, Cal. .30 is especially desirable.

(4) Colors: Red, yellow (or orange), and blue (or white).

(5) Duration of Smoke Emission: Maximum consistent with required density, and not less than one minute.

(6) Size and Density of Smoke Cloud: Sufficient to insure identification of color from an altitude of 10,000 feet. For this purpose the distinctly colored portion of the smoke cloud should cover an area in a horizontal plane of not less than 400 square feet.

(7) Type of Generation of Smoke: Such as to generate minimum of convection currents due to heat.

(8) Manner of Activation: By pull cord for hand operation and by propelling charge for use in a projector.

(9) Weight and Dimensions: Unimportant except as consistent with other characteristics stated herein.

g. Results:

(1) The grenades meet fully the characteristics set forth in Paragraphs (4), (5), (6), (7) and (9), above, and partially the remainder.

(2) They fail to meet those characteristics set forth in Paragraphs (1), (2), (3) and (8) in the following respects:

(a) Par. (1): The grenades cannot be used to generate small clouds of colored smoke in the air between 100 and 300 feet above the ground.

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(b) Par.(2): They are not capable, in their present form, of being projected into the air...for aerial bursts or for generation of the smoke while supported by a suitable parachute.

(c) Par. (3): They cannot be projected with standard pyrotechnic projectors...or from the M1 launcher on the Cal. .30 rifle.

(d) Par. (8): They are not activated by a pull cord for hand operation or by propelling charge for use in a projector. The Test Section believes that the present method of ignition for hand operation, through use of a bouchon type igniter, is superior to a pull cord type of igniter. Previous experiences with pull type igniters have been none too happy.

(e) Experiments were conducted designed to overcome these deficiencies. See Tests 12 to 14, following.

17. Test No. 11

December 29, 1942.

a. Purpose: To answer service questionnaire.

b. Method: Information from tests previously conducted was extracted as needed to answer the listed questions.

c. Results:

(1) Question 1: What effect do the various backgrounds have upon the visibility of the various colored smoke clouds produced by individual and multiple units when observed from the ground and air?

Answer: Insufficient grenades were furnished to test fully against all available backgrounds. The following comments are a result of analysis of information gleaned from limited background tests.

(a) It is self-evident that contrasting backgrounds produce the most effective results.

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Against the typical background of trees, grass and red earth found at Fort Benning, the blue and violet colors faded into the background and were difficult to distinguish at distances in excess of 2000 yards. Red, orange, yellow, and light green were quite easily seen because of their contrast.

(b) On the other hand, against a snow or white beach background, or in desert sand, it is entirely reasonable to assume that blue and violet would be more effective than the remaining colors. Against a light grey cloud background and against a blue sky background these colors showed up better than did any of the others. See Test No. 5.

(c) The red (cerise) grenade was the most generally satisfactory under all conditions of background experienced. Against a relatively dark background, as stated previously, and when haze or woods smoke is present, blue and violet are unsatisfactory at the longer ranges. Against a light sky background, yellow and green fade out completely at ranges greater than 1000 yards. Viewed from the air and from the ground against an earth and tree background, yellow, red and green proved most effective.

(2) Question 2: What effect do extreme temperatures and wind velocities have upon the various colored smoke clouds?

Answer: Extremes of temperature apparently have little effect on the smokes. Winds of course dissipate the clouds and render them relatively less effective in direct proportion to the intensity of the wind. Tests with winds up to 10 mph were satisfactory. It was noted that the yellow smoke appeared to be a light green when dissipated. Red appeared pink when dissipated. The other smokes retained their characteristic coloring.

(3) Question 3: From what altitudes under various weather conditions are the smoke clouds most readily visible?

Answer: The smokes were visible at all altitudes under 10,000 feet when the location of the smokes

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were known to the observers. Background and distance from the display point were more important factors than altitude. Weather conditions encountered during tests varied from high scattered clouds to heavy clouds with a ceiling of 2000 feet.

(4) Question 4: Is the grenade sufficiently waterproof?

Answer: No. Two of six grenades immersed in water failed to fire because water seeped under the tape covering the holes in the top of the cannister and soaked the starting mixture. It was noted that, on many grenades, several of these tapes curled up, exposing the holes in the top of the cannister. In one instance it is believed that the water leaked in around the threads of the bouchon. It is suggested that a better adhesive be used on tapes covering the holes in the top of the cannister and that a washer be provided for the bouchon.

(5) Question 5: Is the colored smoke cloud of sufficient volume?

Answer: That of a single grenade is considered sufficient to meet the requirements for location from an artillery or liaison airplane operating at altitudes of from 600 to 2000 feet and from 1500 to 3000 yards behind our own front lines but unsatisfactory for use with high fast bombers or observation ships. See answer to Question 6, below.

(6) Question 6: Does the grenade burn a sufficient time for best observation?

Answer: The burning time of the grenades is considered greatly in excess of that required for best observation. Tests indicate that a burning time of one minute is adequate. It is recommended that the burning rate be increased, thereby decreasing the burning time, and increasing the volume of smoke produced.

(7) Question 7: Please list any uses for this munition which have been suggested as a result of your tests.

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Answer: No additional uses have been suggested as a result of tests. The grenades are not considered suitable as a signalling device from an airplane to designate to ground parties the location of an opposing enemy force as suggested in Paragraph 7 of the directive. However, they might be dropped over friendly troops to indicate imminent enemy threats, the color being used to indicate the type of danger. A small parachute would probably be necessary to prevent injury to friendly personnel who might be struck by the grenade.

(8) Question 8: Please list any defects or possible improvements in the munition indicated as a result of your tests.

Answer: Tests indicate the following modifications to be necessary:

(a) Improve the waterproofing of the canister by improving the adhesive qualities of the tape covering holes in top of canister and providing the bouchon with a washer.

(b) Make the red color more crimson. It is apt to be confused with the orange at the greater distances, and appears pink when dissipated.

(c) Increase the volume of smoke produced by a single grenade and decrease its burning time to about one (1) minute. It is believed that these two purposes can be accomplished simultaneously by increasing the burning rate.

(d) Increase the amount of coolant in the green smoke mixture to prevent burning.

(e) Improve the yellow color by eliminating as much as possible of the green tinge.

(f) See Results of Tests 13 and 14 for further suggested improvements.

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18. Test No. 12

December 23, 1942.

a. Purpose: To modify the subject grenades so that they might be projected into the air from the M1 launcher of the Cal. .30 rifle.

b. Method: Experiments were conducted to develop a method of fastening the tail fin of the M1A1 antitank grenade to the colored smoke grenades. The grenades were then ignited and fired.

c. Results:

(1) Construction:

(a) In order to approximate the weight of the M30A1 grenade (1.25 lbs.) the smoke grenades were cut in half, the bottom of the cannister fastened to the tail fin, and used as a holder for the remainder of the grenade. The weight of the resultant assembly was 1.28 lbs.

(b) See diagram in Appendix "B" and Plate 6 for construction details and appearance of the resultant grenade.

(2) Activation:

(a) The grenade was activated by placing the assembly upon the M1 launcher, releasing the bouchon lever, thus starting the smoke stream, and when the smoke was fully ignited, firing the assembly from the launcher.

(b) The grenade left a trail of smoke through the air during flight. When fired at an angle of 45°, its trajectory was judged to have a height of 150 feet. Its range was approximately 150 yards. The grenade continued to burn after striking the ground.

(c) Observers felt that the smoke was apt to be deceptive because to an air observer two spots, the point of initiation and the point of fall, were marked on the ground. It was their opinion that this grenade, while it met the requirement of projection, would not be satisfactory because of this deceptiveness.

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19. Test No. 13

December 26, 1942 and January 2, 1943.

a. Purpose: To develop a satisfactory parachute smoke signal by modifying the M17 and M17A1 Ground Signals.

b. Method: Experiments were conducted to develop a parachute smoke signal through modification of the M17 and M17A1 Ground Signals. The resultant assemblies were fired and the results noted.

c. Results:

(1) Construction:

(a) The parachute and flare materials were removed from Ground Signals M17 and M17A1. An improvised cannister of smoke mixture was fastened to the parachute and reinserted in the tube. The smoke canister was made from the inside sleeve of an M10 flare from which all flare elements and fuse had been removed. The caps were then replaced, completing the assembly.

(b) See diagram in Appendix "B" for details of construction.

(2) Activation:

(a) Modified M17 Ground Signal: These signals in various colors were fired from an M4 projector. The parachute and smoke mixture were ejected at an estimated altitude of 500 feet; the smoke material ignited producing a very distinctive signal whose color was readily identified. The burning time of the smoke cannister averaged one minute.

(b) Modified M17A1 Ground Signal: These signals in various colors were fired from the M1 launcher. The resulting signal was identical with that reported in the paragraph above. Burning time averaged one minute.

(c) It was the opinion of observers that this signal was a very effective one, that it was more easily identified than the pyrotechnic during daylight, and that smoke signals in various colors would be valuable as a supplement to the M17-22 series or M17A1-22A1 series of ground signals.

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(3) This signal did not meet the military characteristics for a smoke signal suitable for identifying ground troops to air observers because, (a) it could not be used on the ground, (b) it left no distinct smoke trail to the ground pointing out its point of origin, and (c), its height of trajectory made it difficult to associate its position in the air with any point on the ground. See Infantry Board Report of Test No. 1422.

(4) The Test Section believes that this signal would be extremely valuable as a supplement to the Ground Signals for sending prearranged messages, and as such should be developed immediately, but that it is unsuitable for use in designating positions of forward units to air observers.

20. Test No. 14

January 5, 1943.

a. Purpose: To develop a smoke signal which can be used on the ground as a grenade, or which can be projected from the M1 launcher to a height of over 100 feet, leaving a trail of smoke to indicate its point of origin.

b. Method: Available signals and flares were studied to determine whether any principle exemplified might be employed to answer the requirement for a smoke signal which could be used either as a hand grenade or as an aerial smoke at the will of the user. As a result of this study a means of projecting the subject grenade and suspending it by a parachute was developed. Because some doubt existed in the minds of the test officers as to the practicability of projecting the entire grenade which with its parachute and tail assembly weighed 1.75 lbs., a second lighter cannister was constructed and tested.

c. Results:

(1) Construction:

(a) Subject grenade modification:

(1) See Appendix "H" and Plate 7 for diagrams and photograph of the detailed grenade construction.

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(ii) The assembly utilized the tail assembly of the M17A1 ground signal, the case, powder train, expulsion charge, and parachute of the M9 aircraft signal, and the subject grenade. No alterations were necessary in the tail assembly of the M17A1 ground signal. The case from the M9 aircraft signal was cut to sizes as shown in the diagram in Appendix "H", threaded to receive the tail assembly and packed. A cap from this aircraft signal was fastened to the base of the subject canister and the parachute fastened to a ring set in the cap. The cap with grenade attached was set on the parachute container and taped. Weight of grenade w/cap - 1.12 lbs. Weight of tail assembly w/parachute - .64 lbs. Total 1.76 lbs.

(b) Small size smoke grenade:

(i) See Appendix "I" and Plate 8 for diagrams and photographs of the detailed assembly.

(ii) The small smoke canister was constructed from part of the case of an M9 aircraft signal, to which caps, holes, starting mixture, and bouchon were added as shown in the diagram. The parachute employed was taken from the T1 trip flare. Case construction was as outlined in the paragraph above. Weight of grenade w/cap - 0.71 lbs. Weight of tail assembly w/parachute - 0.54 lbs. Total - 1.25 lbs.

(2) Activation:

(a) Subject grenade modification:

(i) The grenades were placed on the M1 launcher, the grenade ignited, and when a large volume of smoke was being emitted, the assembly was fired from the launcher. One grenade was extinguished by the air blast of firing. Insufficient time had been allowed for complete ignition. The flight was true, and in spite of the weight the assembly reached a height of about 125 feet before ejection. The smoking grenade drifted rapidly to the ground because of their great weight. Burning time of the grenade averaged 2 min. 30 sec. See Test No. 2. They remained in the air for about 20-30 seconds. The base of the M6 aircraft flare case was badly bulged by the discharge. It is not of adequate strength.

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(b) Small size smoke grenade:

(1) The method of projection was identical with that employed for the larger assembly. The flight of these grenades were true. Estimated altitude at time of expulsion was 150 feet. The average burning time was 1' 20". Because the parachute was so small the grenade drifted very rapidly to the earth. It was estimated that they remained in the air approximately 15 seconds. The smoke cloud was quite thick and effective. The base of these grenades was also bulged.

(3) As a result of these experiments the following observations were made:

(a) The principle involved is sound.

(b) The large parachute from the M9 aircraft signal should be used with the smaller smoke cannister to produce the best results.

(c) In view of the fact that the burning time of the subject grenades is excessive, the size, and as a result, the weight of the final type of grenade can be reduced to make it suitable for use either on the ground or by projection following the principles herein outlined.

(d) It was the opinion of the Test Officer that the diameter of the parachute container and grenade should be increased to, (1) increase the volume of smoke and, (2) reduce the length of the assembly.

(4) The Test Section believes that the experiments herein reported point the way toward a smoke grenade meeting all stated military characteristics, a grenade which will be suitable for designating the position of front line units to air observers, and suggests that developmental work be expedited.

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VI DISCUSSION

21. General.

a. It is the opinion of the Test Section, based on Air-Ground Tests reported in Infantry Board Reports Nos. 1353 and 1422 that smoke grenades to be considered satisfactory for use in location and identification of Infantry forward elements must produce a smoke of one minute duration which can be seen at a minimum distance of 5000 yards and whose color can be recognized at a minimum distance of 2000 yards by an airplane flying at any altitude under 10,000 feet. The discussion on the relative effectiveness of these grenades is based upon this opinion.

b. In considering the use of colored smoke grenades a study of backgrounds prior to assignment of uses is necessary. The Test Section believes that the variety of colors offered will enable the Division Signal Officer or other authority to make suitable selections and further believes that the provision for a variety of colors is more satisfactory than the attempted development of two or three colors which might be possibly more effective against all possible backgrounds.

22. Statement of Advantages and Disadvantages.

a. A study of test results indicates the subject grenades to have the following advantages:

(1) The grenades are light, compact and simple to operate.

(2) Their colors, except as noted below, are very distinctive.

(3) Used singly, they are satisfactory as a means of identifying friendly ground troops to the low-flying, slow-flying liaison or observation plane.

(4) Used in pairs, they are satisfactory as a means of identifying friendly ground troops to high-flying bombers or reconnaissance planes.

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b. The grenades possess the following disadvantages:

(1) They cannot be projected into the air from the M1 launcher or from other existing projectors.

(2) They are not sufficiently waterproof.

(3) The green element tends to burn rather than to smoke.

(4) The red element is not sufficiently distinctive to permit ready identification when dissipated or to prevent its being confused with orange.

(5) The burning time is considered excessive. See answers to questionnaire in Test No. 10.

(6) The volume of smoke produced by one grenade is not adequate for positive identification by high-flying fast observation airplanes at the required distances.

23. Recommended Modifications.

a. The Test Section considers the following modifications to be essential:

(1) Improve the waterproofing of the grenades by using a better quality adhesive on the tapes covering the holes in the top of the canister and by providing the bouchon with a washer.

(2) Make the red coloring more crimson, less pink.

(3) Add enough coolant to the green mixture to prevent the grenade from bursting into flame.

(4) Increase the volume and decrease the burning time of the single grenade. The burning time could be reduced to approximately one minute and still provide adequate time for location and recognition of color. It is believed that by increasing the burning rate both these objectives may be attained.

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b. The following modifications are considered desirable:

(1) Remove as much as possible of the green tinge in the yellow smoke mixture.

(2) The size, shape and weight of the grenade should be changed as outlined in Test No. 14, above, in order that projection from the M1 launcher may be accomplished and all military characteristics met.

c. Attention is invited to the experiments reported in Tests 12 to 14 inclusive, designed to develop variations which might be of value as signal agents, and a grenade meeting the military characteristics given in Appendix "B" of this report.

d. In the event that a grenade suitable for use either on the ground or from the M1 launcher is developed as suggested, it is believed that two or more grenades could be issued per tail and parachute assembly.

VII CONCLUSIONS

24. The Test Section concludes that:

a. The subject grenades are satisfactory, when used singly, as a means of identifying and locating the positions of forward Infantry elements to air observers in low-flying slow observation airplanes.

b. They are satisfactory, when used in pairs, as a means of identifying and locating the position of forward Infantry elements to air observers in high-flying fast observation or other airplanes.

c. They are unsatisfactory as a means of identifying a Cub or liaison airplane to ground troops.

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d. They meet all military characteristics except those requiring aerial smoke and projection of the grenade into the air.

e. Modifications recommended in Paragraph 23, above, should be incorporated in final types of the grenades.

f. Colored smoke signals similar to those discussed in Test No. 13, and shown in Appendix "F", should be produced and issued to supplement the M17-22 series and/or the M17A1-22A1 series of Ground Signals, for daytime use.

g. Development of a grenade similar to those discussed in Test No. 14 and depicted in Appendices "H" and "I", which meet all military characteristics, should be expedited.

H. G. SYDENHAM,
Colonel, Infantry,
Chief, Test Section.

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APPENDIX

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IN-471.6

December 15, 1942.

Subject: Colored smoke grenades.

To: The Chief of Test Section,
The Infantry Board,
Fort Benning, Georgia.

1. It is requested that the one hundred and fifty (150) smoke grenades recently received be tested to determine their suitability for identification and location of Infantry forward elements and also for identifying a sub or liaison plane.

2. A report on these grenades will be made a supplement to the report on Artillery-Infantry Test, No. 1428.

For the President:

[redacted],
Lt. Colonel, Infantry,
Acting Recorder.

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ORDNANCE SECTION
HEADQUARTERS
ARMY GROUND FORCES
ARMY WAR COLLEGE
WASHINGTON, D.C.

GNAGT-11/28390 Dec. 10, 1942.

Subject: Service Test of Colored Smoke Grenades.

To: The President, The Infantry Board,
Fort Benning, Georgia.

1. There were shipped to the Infantry Board on December 8, 1942, from Edgewood Arsenal, Maryland, sample lots of 25 each of several different colored smoke grenades. These grenades are designed to provide an even and continuous cloud for at least two minutes, and are provided in the following colors: blue, green, orange, red, violet, yellow and black. The grenade body is the same as the M6, M7 and M8 chemical grenades, equipped with a Bouchon assembly, and a 15 gram starter charge. The colored smoke charge varies from 260 to 340 grams, depending on the color.

2. These grenades were developed originally as a vehicular type grenade, to meet the requirement for colored smoke, for identification purposes. However, the characteristics have been extended to include the following:

a. Purpose: To generate small clouds of colored smoke on the ground or in the air between 100 and 300 feet above the ground, for indicating to friendly aircraft the location of front line elements of ground troops or identifying friendly ground installations and areas.

b. Type and Method of Employment: Small smoke pots or grenades to be ignited and placed or thrown by hand on the ground and also capable of being projected vertically into the air to a height of between 100 and 300 feet for aerial bursts or for generation of the smoke while supported by a suitable parachute. If technically feasible the same ammunition should be susceptible of either method of employment at will.

c. Method of Projection: By hand or with standard pyrotechnic projectors in use by the ground arms. Projection with the AT Launcher on the Rifle, Cal. .30, is especially desirable.

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d. Colors: Red, yellow (or orange), and blue (or white).

e. Duration of Smoke Emission: Maximum consistent with required density, and not less than one minute.

f. Size and Density of Smoke Cloud: Sufficient to insure identification of color from an altitude of 10,000 feet. For this purpose the distinctly colored portion of the smoke cloud should cover an area in a horizontal plane of not less than 400 square feet.

g. Type of Generation of Smoke: Such as to generate minimum of convection currents due to heat.

h. Manner of Activation: By pull cord for hand operation and by propelling charge for use in a projector.

i. Weight and Dimensions: Unimportant except as consistent with other characteristics stated herein.

3. It is desired that these grenades be tested to determine if they meet these characteristics and are suitable for use by Infantry troops. The most desirable colors should be determined and reported. (It is not believed that the grenades furnished are capable of being projected into the air. Experiments for so projecting them are being carried on at Aberdeen Proving Ground.) The test should further include the items given in the inclosed copy of Directive for Service Test of Grenade, Smoke, Colored, M16.

4. It is desired that a basis of issue for infantry be recommended.

For the Chief, Ground Requirements Section:

(Signed)
GEORGE H. DALEY,
Lt. Col., Cavalry,
Assistant Executive,
Ground Requirements Section.

1 Incl.
Directive for
Service Test.

G.R.S.

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Authority NND 963502

IB-471.6
(13-16-42)

1st Ind.

THE INFANTRY BOARD, Fort Benning, Georgia, December 22, 1942.
To: The Chief, Test Section, The Infantry Board.

1. It is requested that this correspondence be included in the Directive for Test of Colored Smoke Grenades previously furnished you. (See letter, file IB-471.6 to The Chief of Test Section, December 15, 1942).

2. In this connection your attention is invited to paragraph 3 of basic letter and to "General Description" and to "Questionnaire" inclosed therewith.

For the President:

E. A. SHADAL,
Lt. Col., Infantry,
Acting Recorder.

1 Incl. n/c.

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~~Directive for Service Test of~~
~~Grenade, Smoke, Colored, M16~~

Section I
General Description

1. General

This directive has been prepared to assist in the service test of the Grenade, Smoke, Colored, M16.

2. Object

a. To determine the effectiveness of this munition as to visibility against various backgrounds.

b. To determine the effectiveness of this munition as to visibility from various altitudes.

c. To determine the effect of extremes of temperature and wind velocity upon the effectiveness of this munition.

d. To determine the tactical uses for which this munition is suitable.

3. Authority

Project Program 1943 Project E 7a-2 Job 90

4. Description of Munition

The Grenade, Smoke, Colored, M16 consists of a cylindrical container approximately 2-3/8 in. diameter by 4-5/8 in. high with three vertical rows of six holes each spaced 120° apart, around the periphery of the container. The container is filled with a colored smoke mixture consisting of a dye, a fuel mixture (sulfur and potassium chlorate) and a cooling agent (sodium bicarbonate). The grenade is fired by an M204A1 Igniting Fuze (Houdon) which ignites the starter mixture consisting of silicon, potassium nitrate and charcoal bound with cellulose nitrate and acetone. The starter mixture in turn ignites the colored smoke filling which burns and emits an appreciable volume of smoke for approximately 2 minutes.

5. Prior Tests

Preliminary tests of the Grenade, Smoke, Colored, M16 have been conducted at Edgewood Arsenal.

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6. Method of Using

The lever of the igniting fuze is held tightly against the side of the grenade by the right hand and the safety ring of the fuze is withdrawn by the left hand. The grenade is either placed or thrown on to the ground. When the fuze lever is released, the fuze is fired. After a 2 second delay, the starter charge is initiated by the fuze and the munition burns.

7. Recommendations for Specific Tests

The Grenade, Smoke, Colored, M6 has been tested at Edgewood Arsenal. The grenades were placed on the ground and visibility of the colored smoke cloud observed from altitudes of from 4000 to 8000 ft. against a background of clay and green brush. It is suggested that the colored smoke grenades be tested as:

a. A signalling device for air to ground liaison at various altitudes against varied backgrounds.

b. A signalling device from an airplane to designate to ground parties the location of an opposing enemy force.

c. A signal for the designation of beachheads in landing operations.

d. A signalling device on snow covered terrain.

8. Comments and Recommendations

The questionnaire attached hereto is to provide an opportunity for the free expression of the views and impressions of this munition obtained by the various agencies as a result of their tests. Any additional tests to aid in the establishment of tactical uses for this munition should be made and reported.

Incl
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Section II
Questionnaire

The following questionnaire is intended to elicit essential information regarding the military value of the Grenade, Smoke, Colored, AN-. Answers to the questions are desired and suggestions for correcting each defect reported are requested.

1. What effect do the various backgrounds have upon the visibility of the various colored smoke clouds produced by individual and multiple units when observed from the ground and air?

2. What effect do extreme temperatures and wind velocity have upon the various colored smoke clouds?

3. From what altitudes under various weather conditions are the smoke clouds most readily visible?

4. Is the grenade sufficiently waterproof?

5. Is the colored smoke cloud of sufficient volume?

6. Does the grenade burn a sufficient time for best observation?

7. Please list any uses for this munition which have been suggested as a result of your tests.

8. Please list any defects or possible improvements in the munition indicated as a result of your tests.

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13-471.6

November 15, 1[illegible].

Subject: [illegible], Colored smoke.

To: Chief, Ground Organization,
Ray Ground Forces, Ray Air Force,
Washington, D. C.

1. The Infantry Board received on November 14, 1[illegible], one hundred and fifty (150) colored smoke grenades in the following colors:

25 - Yellow
25 - Orange
25 - Green
25 - Blue
25 - Red
25 - Violet

2. It is assumed by the Infantry Board that these grenades were shipped here for inclusion in the Infantry-Artillery Liaison Test, which has been completed and report thereon is now being prepared.

3. The Infantry Board will test these colored smoke grenades and will submit report to your office.

For the President:

[illegible],
Colonel, Infantry,
Director.

[illegible]

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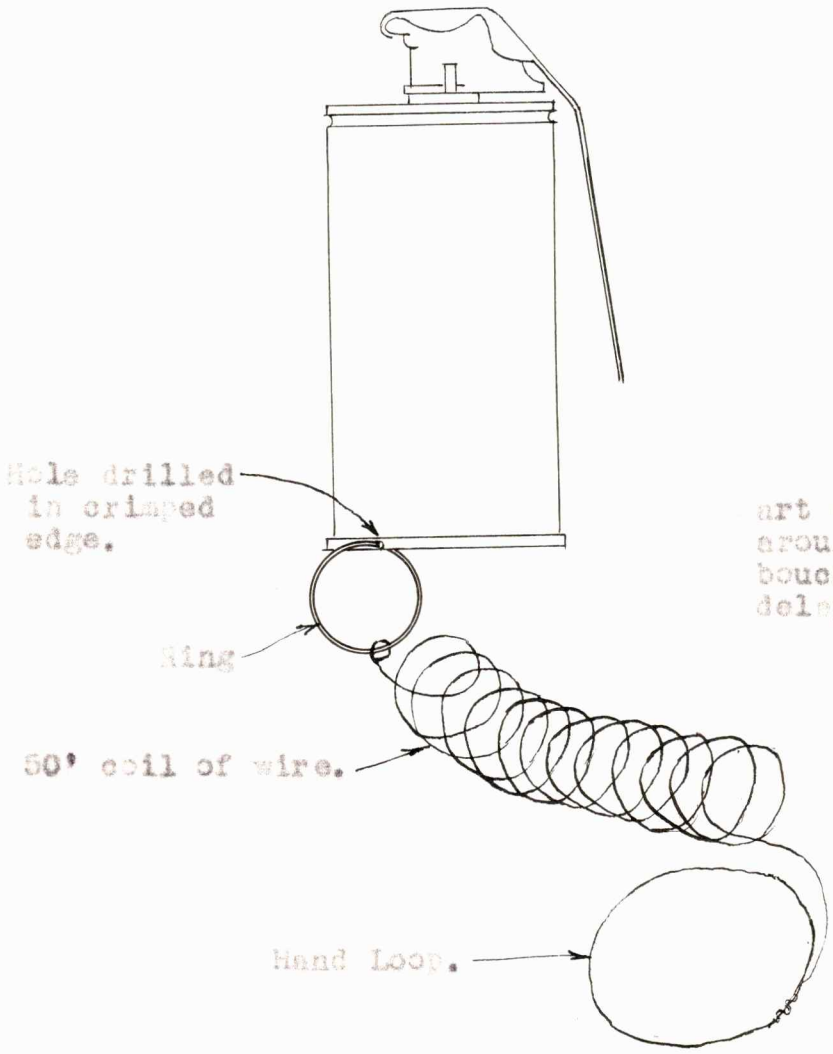
Authority NND 73[illegible]



art of coil is wrapped around cannister and bouchon lever to provide delayed ignition.

Subject Grenade Modified For Use from Airplanes.

Scale: 1/2 Size.

APPENDIX "D"

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Cut here

Grenade, Hand, ...

Fig. 1

Cut here

Grenade, Hand, ...

Fig. 2

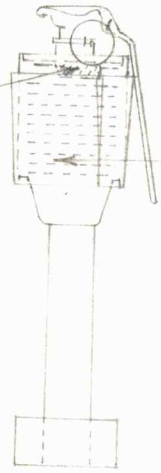

Fig. 4

Complete grenade ready for projection from rifle launcher

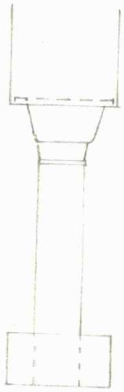

Fig. 3

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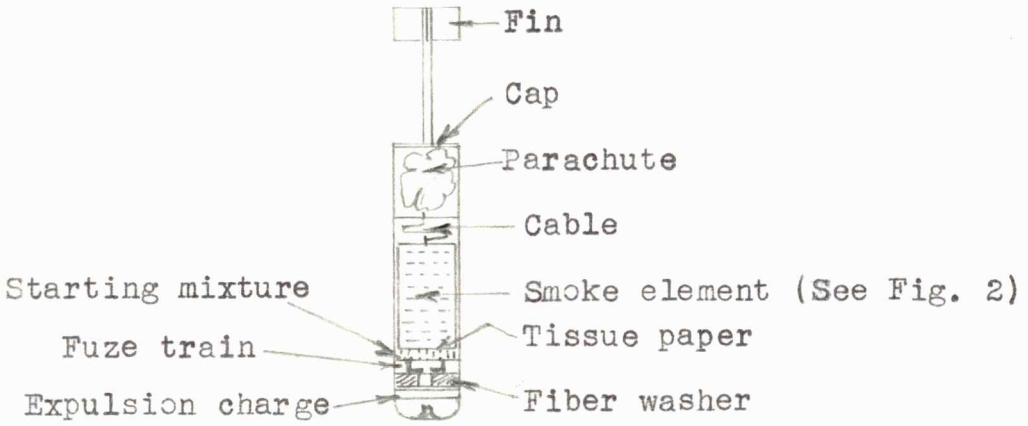

Fig. 1

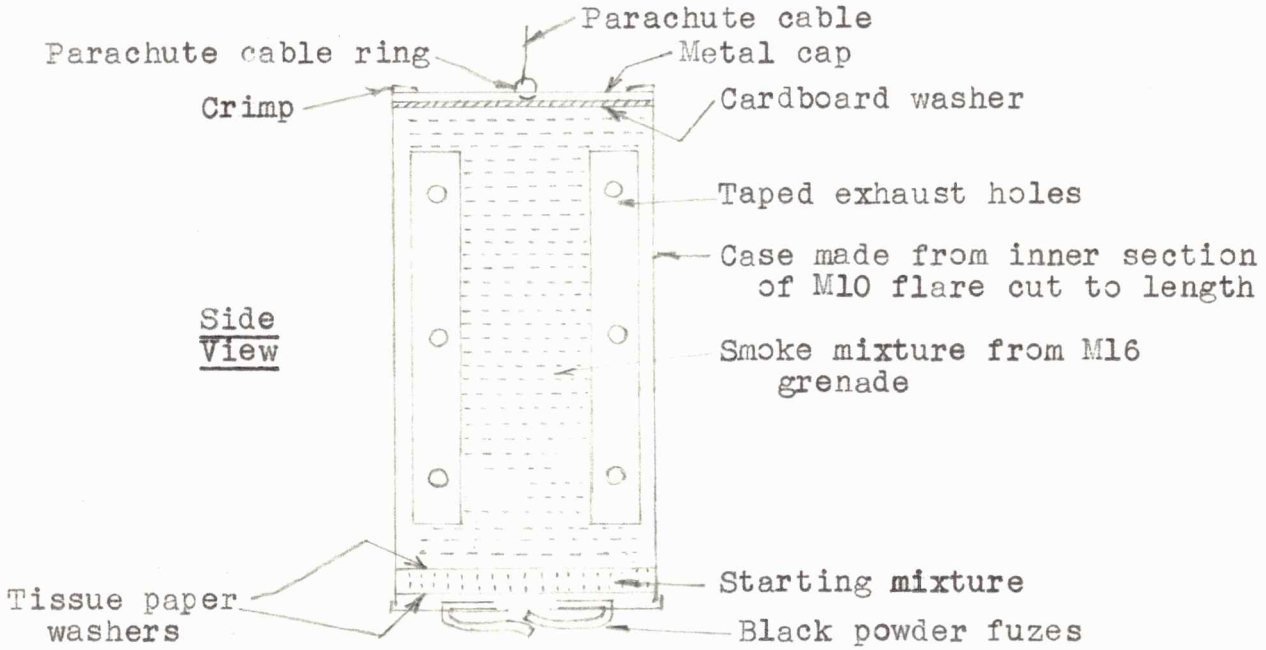

Fig. 2

APPENDIX "F"

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Colored Smoke Grenades
Test No. 5

Observer _____

Altitude: 600 feet - 1500 feet (Mark out one)

Flight Number

Distance	1		2		3		4		5		6	
	Seen	Color	Seen	Color	Seen	Color	Seen	Color	Seen	Color	Seen	Color
Point R 6000 yds												
Line A 5000 yds												
Line B 4000 yds												
Line C 3000 yds												
Line D 2000 yds												
Line E 1000 yds												
O P Overhead												

Instructions: Check position of flare when smoke was first seen (under column labeled "Seen") for each flight. In column marked "Color" write your opinion of the color of the grenade seen for each line of each flight. All color blanks on this page should be filled at conclusion of test. Record any comments below.

_____

_____

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AIR OBSERVER QUESTIONNAIRE

COLORED SMOKE GRENADES

Test No. 6

Pilot _____. Altitude _____

1. Instructions: Your mission will include six flights. For each flight check the distance of the plane from Jackson Hill when smoke is first seen and record the color you believe the smoke to be as you cross each line. At the completion of each flight return to rendevous point and await radio orders for next flight.

2. Series 1: Single grenade.

FLIGHT NUMBER

Position on Course	1		2		3		4		5		6	
	Seen:	Color:	Seen:	Color:	Seen:	Color:	Seen:	Color:	Seen:	Color:	Seen:	Color:
Rendevous 6000 yds.												
Line A 5000 yds.												
Line B 4000 yds.												
Line C 3000 yds.												
Line D 2000 yds.												
Line E 1000 yds.												
O. P. Overhead												

APPENDIX "E"

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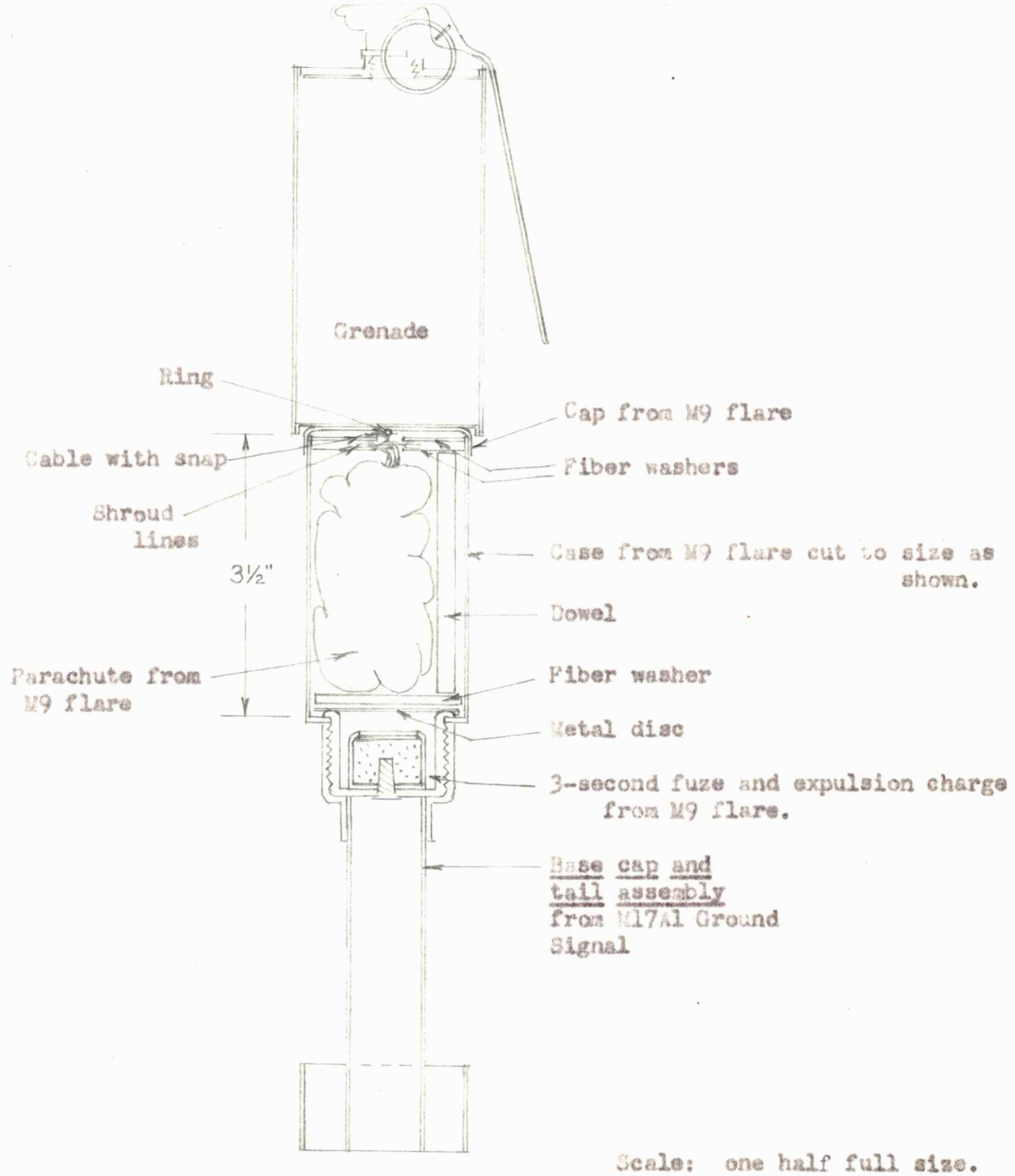

Scale: one half full size.

APPENDIX "H"

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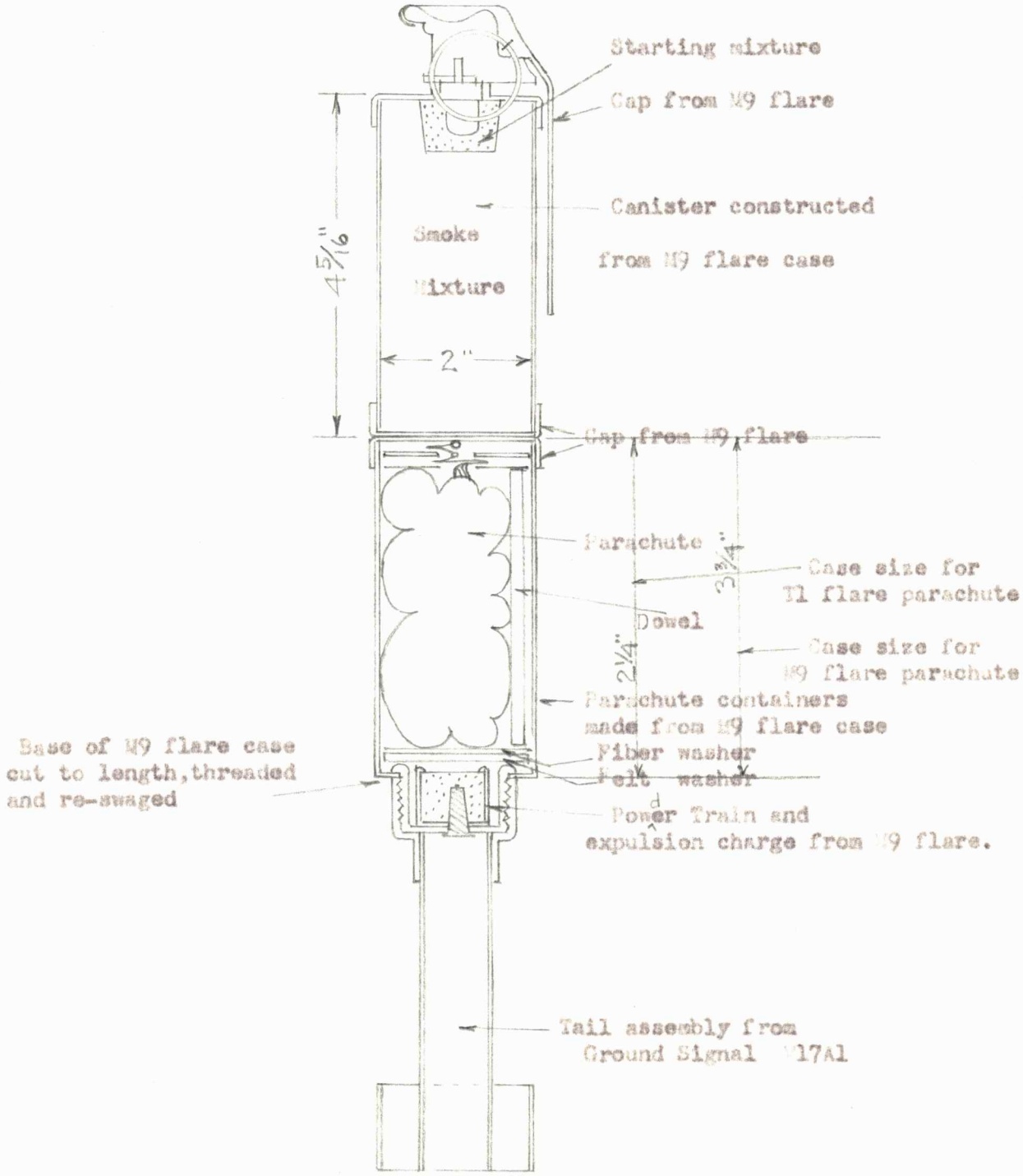

An Experimental Dual Purpose Smoke Grenade

APPENDIX "I"

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a b c d e f

Colored Smoke Grenade

a - Red
b - Orange
c - Yellow
d - Green
e - Blue
f - Violet

Plate 1

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43613-7

Colored Smoke Grenades
with bouchons separate.

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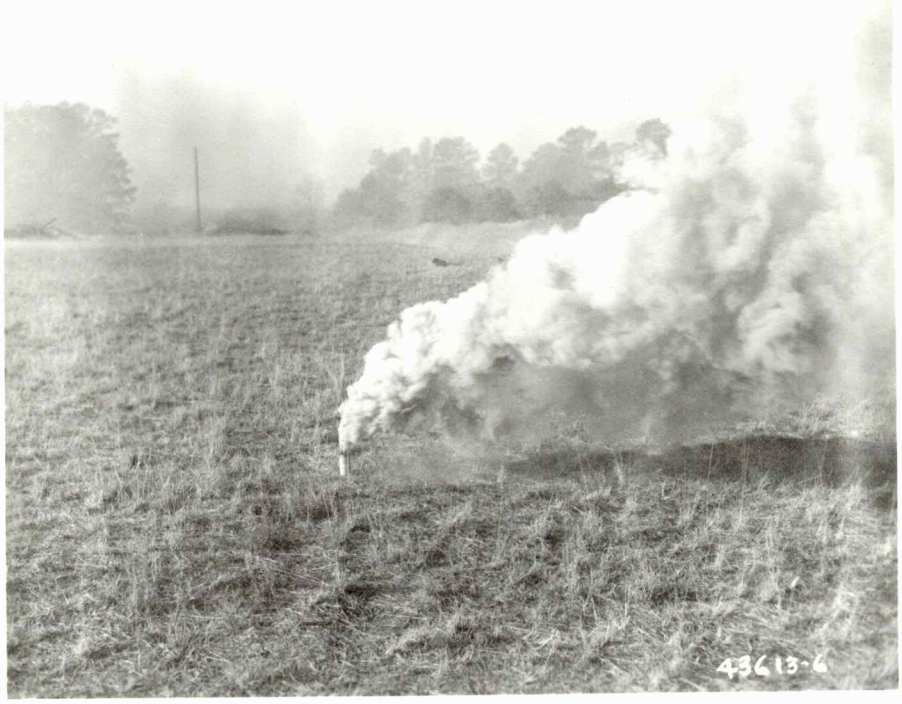

Colored Smoke Grenades.

Illustrating volume of smoke
from one grenade.

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Colored Smoke Grenades

Illustrating smoke cloud from two grenades set a few feet apart.

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Colored Smoke Grenades

Grenade modified for use from
Liaison Plane.

See appendix "D"

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Colored Smoke Grenades

Initial modification of grenade
for projection from M1 launcher.

See appendix "E"

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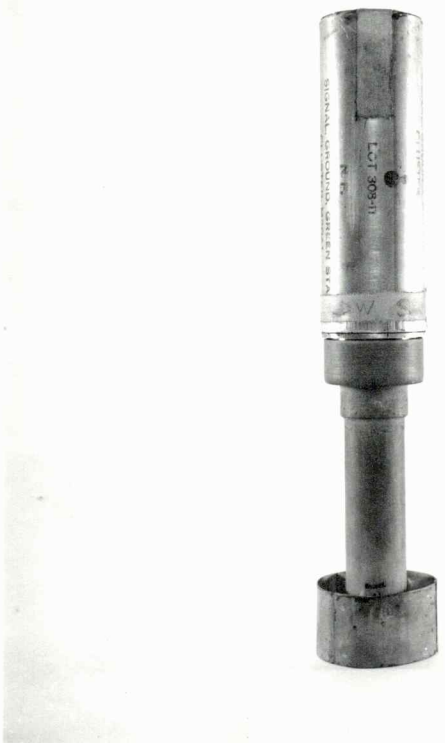

Colored Smoke Grenade

M17A1 Ground Signal modified as a parachute smoke. See Test No. 13.

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Colored Smoke Grenade

Subject grenade modified for projection from M1 Launcher.

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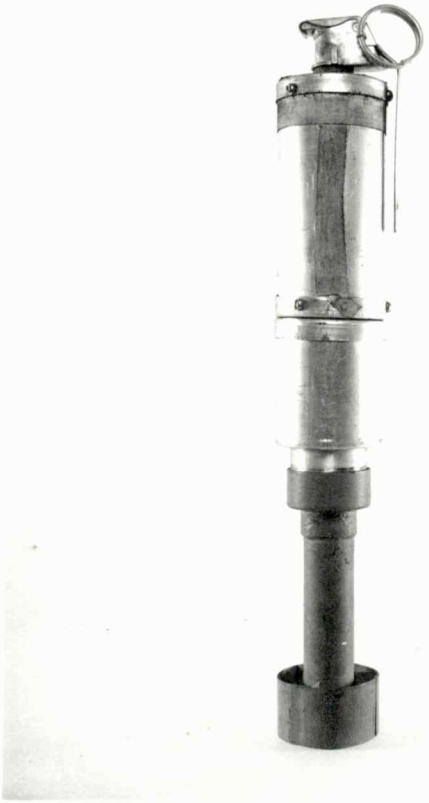

Colored Smoke Grenade

Small size dual purpose smoke grenade.

See Test No. 14.

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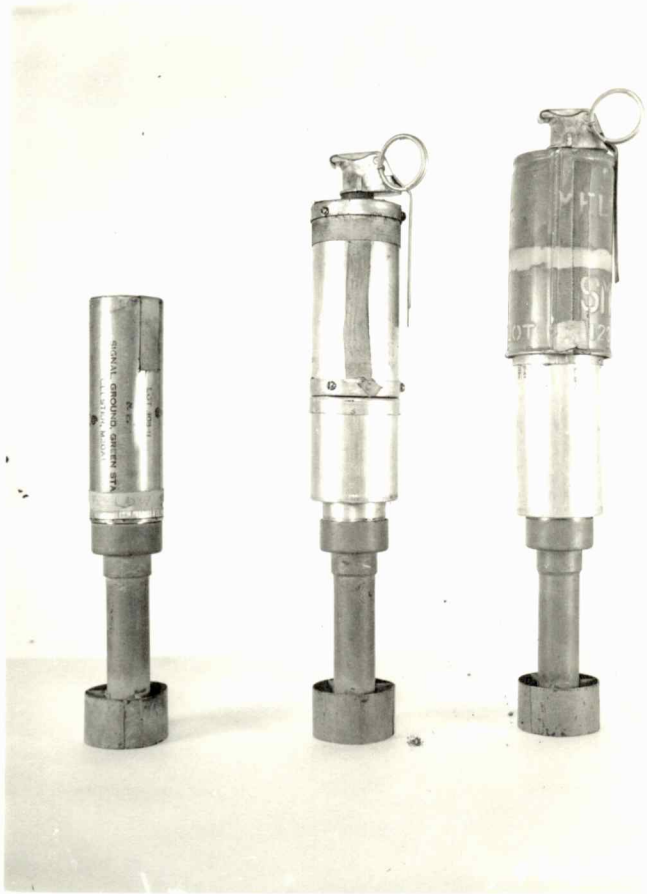

Colored Smoke Grenades

Showing relative sizes of experimental smoke described in Tests 13 and 14.

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